Calcareous Concretions and Sheets in Soils Near South Point, Hawaii[1]

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WHITE CALCAREOUS concretions and sheets are found in the soils of the Pakini series of the Reddish Brown great soil group in the South Point area of the Kau section on the island of Hawaii. These soils have developed on a series of wind-deposited volcanic ash as described by Palmer (1931) and Wentworth (1938). The calcareous concretions found in these soils have been formed by biogenetic processes in that the carbonates have been precipitated around the roots of plants, especially the deep-rooted plants. These rhizo-concretions occur only in the subsoil, B horizon, of the soil profile. The calcareous sheets occur as layers in the parent material of this soil which is the aeolian silt and sand. The character of the effervescence of these calcareous depositions indicates the presence of appreciable quantities of dolomite in the carbonate fraction of these materials. Wentworth (1938) has reported the occurrence of both calcareous stem casts and calcareous sheets in overlying, looser aeolian ash of this area. The occurrence of calcareous rhizo-concretions has been mentioned by Bryan (1952) in his report on soil nodules. The occurrence of dolomite in soil concretions has not been described; however, the occurrence of dolomitization in soils has been described by Sherman *et al.* (1947).

This study was initiated to determine the nature of the composition of these calcareous rhizo-concretions and sheets. In order to do this, samples of these materials were collected and analyzed by methods designed to determine the composition of carbonates in soils as described by Sherman (1937).

The samples were collected from an area of soils which had been classified by Cline *et al.* (1955) as the Pakini very fine sandy loam—a soil which has developed from the moderate weathering of a series of layers of volcanic ash. The surface horizon of about 5 to 6 inches is dark-brown very fine sandy loam (A_{11}) over a slightly lighter colored very fine sandy loam (A_{12}) of varying thickness. The total thickness of the combined A_1 horizon does not exceed 15 inches. The material below the A horizon is a B horizon of yellowish-red silty material containing sand and gravel. In places a weak blocky structure has developed in contrast to the crumb structure of the A horizon. This material gradually grades into a reddish-yellow silt loam in which continuous white layers (sheets) of carbonates occur as bands about half an inch in thickness. The carbonate-coated decayed roots of plants of the previous original vegetation of the area occurred in this layer and in the B horizon immediately above it and at a depth of 36 to 58 inches below the surface. The original vegetation has been removed and replaced by grasses suitable for grazing.

The rhizo-concretions of carbonates are shown in Figure 1. They retain the general shape of the root. The concretions in the center row of the illustration show a deposition layer on the outer surface of the root and a mixture of carbonates and decomposed organic material in place of the root in the center of the concretion (inner portion). The outer

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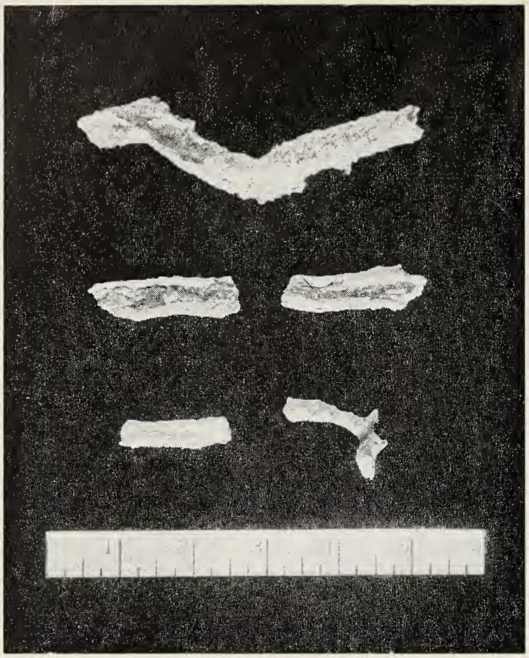

FIG. 1. Calcareous rhizo-concretions found in soils near South Point, Hawaii. Size of concretions can be compared with the scale shown in inches.

layer apparently was deposited around the living root and the inner portion was deposited after decomposition of the root at a later time. The outer layer was comparable in appearance to the calcareous layers or sheets in the soil. The deposition of the carbonate appeared to occur on the surface of very fine texture layers occurring in the wind-blown materials, usually clay layers. Samples were collected to represent the outer and inner portions of rhizo-concretions and the sheets.

The data obtained from the chemical analysis to determine the composition of the carbonates are presented in Table 1. The total carbonate content of the inner portion of the rhizo-concretions was found to be a little less than 82 per cent, the highest carbonate concentration of the calcareous concretions. The total carbonate contents of the outer portion of the rhizo-concretion and of the calcareous sheets were almost identical, ranging from 65 to 67 per cent. This would suggest that the outer portion of the rhizo-concretions and the calcareous concretions were formed by similar processes of precipitation. These latter calcareous depositions are dense and hard while the carbonate material inside the tubular rhizo-concretions is soft and powdery; thus, the latter depositions constitute only a small portion of the total carbonates. The powdery carbonate of the inner tubular structure could have been precipitated from the waters carrying bicarbonates of calcium and magnesium. The precipitation by the action of alkaline earth elements on ammonium carbonate developed by the decomposing organic matter as suggested by Mathias (1931) should not be discounted. The outer portion of the rhizo-concretion and the sheets were probably precipitated by the precipitation of particles of carbonate near the root or in the more alkaline soil layer and the precipitation of bicarbonates continues due to increasing alkalinity, a process proposed by Gillam (1937). Similar rhizo-concretion formation of pyrolusite has been described by Sherman *et al.* (1949).

The data in Table 1 show an appreciable quantity of magnesium carbonate in these concretions. The highest content was found in the inner portion of the rhizo-concretions which was found to contain 23 per cent magnesium carbonate, in other words, a little over 62 per cent of the carbonates was in the form of dolomite. The outer portion of these concretions contained 17.0 and 16.5 per cent magnesium carbonate, or in other words, 56 per cent of the carbonates were in the form of dolomite. The calcareous sheets contained 18 per cent magnesium carbonate, equivalent to 58 per cent of the carbonates in the form of dolomite. Thus, active dolomitization is occurring in the formation of these concretions. The determination of exchangeable cations in these soils has revealed a high content of exchangeable magnesium. The high magnesium saturation in the exchange complex is the result of a high content of magnesium ions in the waters which circulate through the weathing system. This would also give an ample supply of magnesium to form the magnesium

TABLE 1
The Chemical Composition of the Carbonates in Rhizo-concretions and Calcareous Layers Occurring in the Soils of the Pakini Series, South Point, Kau, Island of Hawaii

Sample	Total carbonates	Minerals other than carbonates	$CaCO_3$ in sample	$MgCO_3$ in sample	Carbonates as dolomite	$K = \frac{CaCO_3}{MgCO_3}$
	Per cent	Per cent	Per cent	Per cent	Per cent	
Rhizo-concretion #1 inner portion	81.6	14.2	58.5	23.1	62.1	1.61
Rhizo-concretion #1 outer portion	66.1	25.3	49.1	17.0	56.5	1.77
Rhizo-concretion #2 inner portion	81.7	14.4	58.4	23.3	62.5	1.60
Rhizo-concretion #2 outer portion	65.4	25.2	48.9	16.5	55.2	1.81
Calcareous sheet #1	67.3	28.6	49.3	18.0	58.4	1.71
Calcareous sheet #2	67.3	28.5	49.4	17.9	58.2	1.72

bicarbonate which would be essential to the process of dolomitization. Since calcium ions occur in a greater concentration, the precipitated carbonates would show an excess of calcium carbonate. Thus, the rhizo-concretions and sheets should be considered to be dolomitic lime depositions.

SUMMARY

The results of this study have resulted in the following conclusions. The highest total carbonate and carbonates in the form of dolomite occur in the inner portion of the calcareous rhizo-concretions. The similarity between the composition of the outer portion of the rhizo-concretions and the calcareous sheets indicates that these concretionary depositions occurred under the same conditions and are undoubtedly deposited by the same process. The proportion of magnesium carbonate in all of these concretions indicates that active dolomitization is occurring and that dolomite is being deposited in the concretion. These concretions should be considered as dolomitic lime concretions.

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